FOREST RESEARCH NOTES

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NUCLEAR PROBE COMPARED WITH OTHER SOIL MOISTURE MEASUREMENT METHODS

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Soil moisture measurement has been a tedious, laborious, time-consuming job. Many worthwhile soils investigations have been limited by excessive manpower demands. The first "break through" came a few years ago with the development of electrical resistance methods by Bouyoucos and Colman which considerably simplified soil moisture measurement procedures. Now, soils investigators have an even more promising new measurement tool available—the nuclear probe.

Last summer, at the San Dimas Experimental Forest[2/] in southern California, we had the opportunity to compare this new device with gravimetric sampling and long-established Colman fiberglas soil moisture units. The results were gratifying.

Briefly, the principles of the nuclear probe are:

1. Fast neutrons emitted from a radioactive source are slowed down or "moderated" by collisions with hydrogen atoms in the surrounding material.

2. Most of the hydrogen in the soil is in the water form. Therefore, the number of moderated or slow neutrons is a measure of the water content of the soil.

3. Although neutron moderation by materials other than water may occur, it is negligible in most soils. The occurrence of slow neutrons is practically independent of soil texture, structure and aggregation. Therefore, one calibration curve can be used for a wide variety of soils.

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2/ Maintained by the California Forest and Range Experiment Station, U.S. Department of Agriculture, in cooperation with the California Division of Forestry.

The equipment we used consists of a Nuclear-Chicago Corporation Model P19 moisture probe with its fast-neutron source and slow-neutron detector. The count rate of slow neutrons is recorded and timed on a Nuclear-Chicago Model 2800 portable scaler.

The San Dimas large lysimeters[3/] provided an excellent opportunity to compare the new equipment with Colman units and gravimetric sampling. The lysimeters contain 6 feet of sandy loam soil of uniform texture and density. A grass-covered lysimeter was selected for the first test because it was expected to give the greatest range in soil moisture conditions—dry near the surface and wet near the bottom.

After recording Colman unit readings, gravimetric samples were taken at a point about 15 inches from the units. Samples were taken at 3-inch intervals through the first 3 feet, and at 6-inch intervals from 3 to 6 feet. A 2-inch diameter orchard type auger and standard laboratory procedures for soil moisture determinations were used.

A permanent 21 gage, 1 5/8-inch outside diameter brass access tube was installed vertically in the soil the full 6-foot depth. Lysimeter soil, available in a nearby storage house, was carefully packed around the outside of the tube to insure a snug fit. The tube extended 6 inches above the ground surface.

In operation, the probe in its shield is placed on top of the access tube. It is then lowered through the shield to the desired depth (fig. 1). Probe readings were taken at 6-inch intervals through the first 2 feet and at 12-inch intervals to the bottom.

Figure 1.--The nuclear probe is proving to be a fast, accurate method for determining soil moisture. Measurements can be repeated at the same location and depth, and readings are directly convertible to inches of water in the soil profile.

3/ Concrete runoff and percolation tanks 10 feet by 21 feet by 6 feet deep, established in 1937.

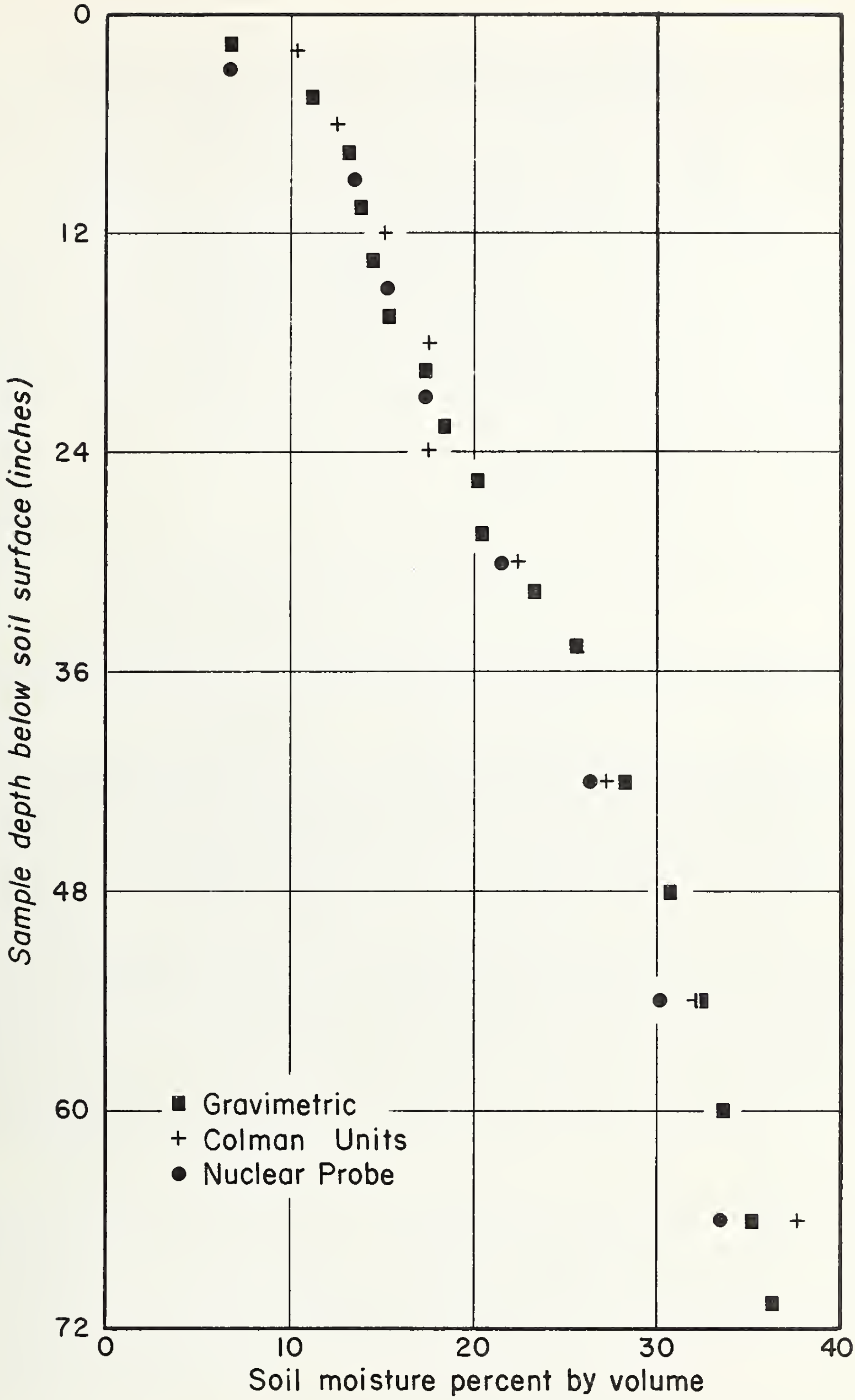

Figure 2.--Soil moisture percent by volume in grass-covered lysimeter, July 11, 1958.

The first gravimetric sampling, July 11, 1958, made immediately after tube installation, showed 17.59 inches of water in the soil profile; the Colman units recorded 17.74 inches, and the nuclear probe 16.58 inches. The calibration curve provided by the probe manufacturer was used in this test. The relationship between moisture percent by volume determined at each sampling point by each method is shown as figure 2. The discrepancy between probe and other determinations was probably due to the dry soil used to fill the space between the auger hole and the access tube. This inserted soil apparently approached equilibrium with the surrounding soil within 5 days. On July 16, Colman units recorded 17.65 inches of water and the probe recorded 17.72 (fig. 3). Remeasurements 6 weeks later, August 29, gave similar results. Colman units recorded 17.22 inches of water in the profile, and the probe recorded 17.15 inches.

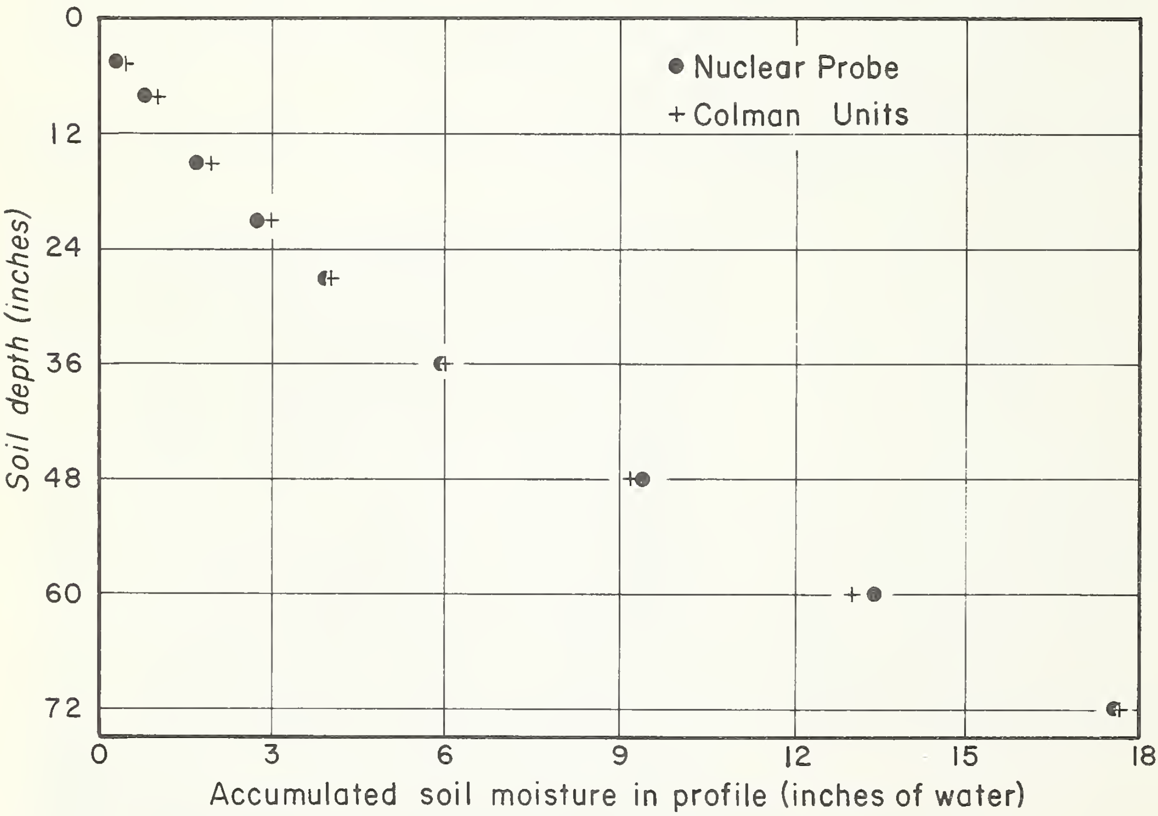

Figure 3. --Accumulated moisture in soil profile of grass-covered lysimeter, July 16, 1958.

Another comparison of the three techniques was obtained in a nearby bare lysimeter. On July 30, a tube was installed and soil moisture measurements were made. On this date, gravimetric sampling measured 18.02 inches in the profile and the probe recorded 17.42 inches. Here again, there is a reduction in probe readings due to back filling. The Colman units from 12 inches to 42 inches in the bare lysimeter failed to check with gravimetric and probe readings. The units recorded 3.3 inches more water, than the probe. One month later, August 29, a 3.1-inch difference between unit and probe readings was recorded. The fact that the probe and gravimetric values were essentialy the same indicates a shift in the calibration curve of these Colman units. Further sampling is under way to determine its extent.

Our brief test, along with extensive research by soil scientists and other researchers, indicates the usefulness of the nuclear probe in soil moisture studies. Some advantages of this new technique are:

1. Sampling is limited only by the depth to which access tubes are installed.
2. Successive samples can be taken from the same point and additional samples at intermediate points can be made if desired.
3. Time required for field sampling is intermediate between gravimetric and electrical resistance techniques. However, computation time is greatly reduced from either method since the field data obtained is directly convertible into inches of water in the soil profile.

The technique is not a panacea, however. Disadvantages do exist. The original cost of the sampling equipment and preparation of sampling sites is high. A radiation hazard is present although the equipment and its shielding have been found to be safe when recommended safety precautions are used. Also, corrections for soil moisture determinations made in the upper 18 inches of soil may be required because of the escape of neutrons into the air at the soil surface.

Extensive soil moisture measurements of 4 watersheds using the nuclear probe will begin at San Dimas during the winter of 1958-59. We expect to obtain more and better data about soil moisture conditions on the chaparral covered mountain watersheds of southern California than has heretofore been available. This will be a big step forward in planning the management of these watersheds for increased water yield and other human benefits.